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Session: 6B - TRASH OR TREASURE? MMS GUIDELINES AND METHODOLOGICAL PROCEDURES FOR IDENTIFICATION OF SUBMERGED MAGNETIC ANOMALIES BY THE COMMERCIAL DIVING INDUSTRY

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Trash or Treasure? MMS Guidelines and Methodological Procedures for Identification of Submerged Magnetic Anomalies by the Commercial Diving Industry	Dr. Richard J. Anuskiewicz Dr. Jack B. Irion Minerals Management Service Gulf of Mexico OCS Region

TRASH OR TREASURE? MMS GUIDELINES AND METHODOLOGICAL PROCEDURES FOR IDENTIFICATION OF SUBMERGED MAGNETIC ANOMALIES BY THE COMMERCIAL DIVING INDUSTRY

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INTRODUCTION

Why Are We Here This Afternoon?

This session was formed to address several issues and problems related to the current methodological procedures that commercial diving companies are using to locate submerged magnetic anomalies in the Gulf of Mexico. Let us begin with a brief background as to why the oil and gas industry is required to conduct archaeological surveys and subsequent investigations on the Outer Continental Shelf (OCS).

National Historic Preservation Act of 1966, As Amended

The National Historic Preservation Act of 1966, as amended, states that the Minerals Management Service (MMS) as a Federal Bureau is required to ensure that the activities it funds (e.g., environmental studies) and the activities it permits (i.e., lease sales, plans of exploration and development, and lease term and right-of-way pipelines) do not adversely affect *significant* archaeological resources.

What Constitutes Archaeological or Historic Significance

Section 106 of The National Historic Preservation Act is a project review process that ensures that the MMS weighs preservation into the balance with the projected benefit, cost and other factors of a completed undertaking. Section 106 extends only to National Register-listed or eligible resources. Section 60.4 of the Act defines a "significant" resource as one that possesses qualities that will yield important information in American history, architecture, archaeology, and engineering. There are four specific "qualities" defined in Section 60.4 and the area we are interested in is Section 60.4, Part (d). Part (d) says that the type of archaeological information we are seeking should yield or be likely to yield information important in history or prehistory.

How Does this Law Specifically Pertain to MMS Activities?

I mentioned earlier that the MMS permits exploration, development, and pipeline construction. To facilitate this process, the MMS has conducted a series of archaeological baseline studies to determine where on the OSC archaeological resources may occur. Therefore, prior to permitting any of these activities, the MMS requires a lease operator to conduct a remote-sensing survey, prepare an archaeological review of the geophysical data, and submit this information in report form to the MMS.

MMS's Written Guidelines for Compliance, NTL 91-02, and 30 CRF 250.26

The MMS Gulf of Mexico Region has prepared sets of report writing guidelines and archaeological compliance procedures for operators, geophysical companies, and archaeologists. In December 1991, I wrote Notice to Lessees 91-02 entitled, "Outer Continental Shelf Archaeological Resource Requirements for the Gulf of Mexico OCS Region," and this NTL was issued to the oil and gas industry. About three years later, our Headquarters office formalized NTL 91-02 by publishing an new archaeological rule in the Federal Register as 30 CRF 250, 256, 280, and 281, titled "Archaeological Resources Surveys and Reports on the Outer Continental Shelf Lease Tracts."

FEDERAL LAW REQUIRES THAT SIGNIFICANT ARCHAEOLOGICAL SITES NOT BE ADVERSELY AFFECTED BY A FEDERALLY PERMITTED ACTION

So, what does all this NTL business and/or archaeological regulation mean to the operator? Remember the reports that have to be submitted to the MMS? The Archaeological Resource Management Program uses these remote-sensing surveys and report evaluations either to clear a lease block of resource potential or to provide information to require additional archaeological survey and testing. If the survey identifies an area of high archaeological potential within a lease block, the lease operator must either avoid these areas during development, or they must conduct

additional surveys and testing if they choose not avoid the potential resource areas. If the archaeological testing indicates that proposed exploration or development will impact significant archaeological resources the lease operators must begin a consultation process with state and federal agencies. This consultation process includes meeting with the State Historic Preservation Office (SHPO) of the affected State, and meetings and discussions with the President's "Advisory Council on Historic Preservation" (ACHP). Both agencies have an opportunity to comment on the proposed undertaking and may provide mitigative guidelines and a Memorandum of Agreement on how to proceed prior to any type of seafloor disturbance. All parties involved (the lease operator, the MMS, the SHPO, and ACHP), must come to an agreement *before* the operator construction can proceed.

WHAT ARE SUBMERGED MAGNETIC ANOMALIES?

There is no way to know if a significant archaeological resource exists in a lease block if you don't look. Historical studies are limited in their usefulness. If the locations of historic shipwrecks are known at all, their positions are only accurate to within miles of their true location. As a result, electronic search techniques are required to locate potential archaeological resources. One of the principal instruments employed for this use is the proton magnetometer, which registers magnetic anomalies in the survey area. Magnetic anomalies are localized disturbances in the earth's magnetic field measured in units of nanoTeslas (nT) or, more commonly, gammas (γ). In Gulf waters, the normal, ambient field measures around 50,000 γ. Magnetic anomalies may be negative, indicated by a drop in the gamma count, positive, with a rise in the gamma count, or bipolar, indicated by both a rise and fall in the gamma count. The signature characteristics relate to the orientation of the object's magnetic pole to the sensor.

Magnetic Anomalies May Be Caused by a Variety of Sources, Both Natural and Man-Made

On the Outer Continental Shelf (OCS), broad, low-amplitude magnetic anomalies may result from buried fluvial channels whose fill exhibits magnetic properties different from the surrounding strata. *Methane seeps* also have been demonstrated to produce magnetic anomalies. Accumulations of pyhhrite and magnetite associated with these seeps have been shown to produce anomalies measuring 100 γ or more (Irion and Heinrich 1994).

By far the most common cause of magnetic anomalies on the OCS is *"modern marine debris,"* a fancy term for trash. A considerable amount of ferrous junk has wound up on the seafloor: steel cable, machine parts, steel belted radial tires, crab traps, refrigerators, and outboard motors to name just a few.

Why go to the trouble of looking for magnetic anomalies, then? As my colleague, Dr. Anuskiewicz, has pointed out, Federal law requires that the MMS consider the effect of any permit action on significant archaeological resources. One other possible cause of magnetic anomalies on the seafloor is *historic shipwrecks*. Historic shipwrecks can be a significant archaeological resource.

What makes historic shipwrecks important? The United States, as we know it today, would not have been possible without ships. Ships carried European explorers to our shores and provided the connective links of a developing nation. Over more than 200 years, they have fought our wars, carried our settlers, and transported our commerce. Now, most of our maritime traditions are lost and our historic ships have gone to the shipwreckers or sunk to the bottom of the sea. By preserving and studying shipwrecks, marine archaeologists hope to be able to reconstruct history and to understand better what life was like during the Age of Sail and the Age of Steam. Skillfully excavated, they tell us how our ancestors lived, how we came to be who we are today, and who we may become tomorrow. Our submerged cultural heritage is a national treasure we must protect so that we, in turn, can pass these resources to future generations for their enjoyment and education. By identifying historic shipwrecks in the remote sensing record, we are taking the first step, in conjunction with industry, towards preserving our national heritage.

Unfortunately, the magnetometer doesn't scream out "shipwreck!" Instead, it records numbers and squiggly lines; the job of the archaeologist is to interpret those numbers. Many attempts have been made to characterize the types of magnetic signatures made by shipwrecks. Clausen (1966) and Clausen and Arnold (1975:169) suggested, in an examination of early sailing vessels in Florida and Texas, that their signature consisted of "a central area of magnetic distortion characterized by a number of intense and generally localized anomalies surrounded and, depending upon the depth and dispersion of the wreck, sometimes, interspersed by scattered, smaller magnetic disturbances." Later work by Watts (1980) demonstrated that

shipwreck sites can generate minimal signatures, producing broad-based, 20-gamma anomalies. A magnetic survey of known eighteenth-century ferries in the Cape Fear River near Wilmington, North Carolina, produced no reliably detected signature (Watts 1983).

Studies conducted on vessels dating after 1850 suggest that large ships of this period generate magnetic disturbances in excess of several hundred gammas. Work on iron or steel hulled ships of the Civil War period by Watts (1975), Cussler (1981), Irion (1986), Garrison and Anuskiewicz (1987), and Arnold and Anuskiewicz (1995) indicate that such vessels produce a signature that is bi-polar or multi-component in excess of 1,000 gammas. Efforts directed at groundtruthing similar anomalies in Mobile Bay revealed that modern debris can generate virtually identical signatures (Irion and Bond 1984, Irion 1986). Archaeological groundtruthing on the Tombigbee River (Saltus 1976, Murphy and Saltus 1981); on the Elizabeth River, Virginia (Watts 1982); in Mobile Bay (Irion and Bond 1984, Irion 1986); and in Matagorda Bay, Texas (Arnold 1982) established that, while there are characteristics that can be associated with various types of shipwreck sites, it is impossible to identify them on the basis of magnetic signature alone. Watts (1986:14) observed that "the remains of vessels can be demonstrated to generate every type of signature and virtually any combination of duration and intensity." Given our inability positively to identify shipwrecks from magnetometer records, industry is left with several options in order to comply with the National Historic Preservation Act.

OBJECTIVES

Should the Oil and Gas Industry Avoid or Test Unidentified Magnetic Anomalies?

This is very interesting question. First of all, when Dr. Irion and I do our archaeological review and make a mitigative recommendation, these recommendations are always posed by us to provide options. The archaeological resource management program at the MMS never makes a decision "for" the operator. We provide options. These options are (1) avoid the anomalies by re-engineering, (2) groundtruth the anomalies by using divers, or (3) don't construct the project.

Relocate Anomalies on the Seafloor

Relocating unidentified magnetic anomalies recorded on or below the seafloor can be a difficult task. However, with the present state of technology transfer, high-tech magnetometer surveys are becoming commonplace and the use of Differential Global Positioning Systems technology is becoming the rule rather than the exception. Geophysical companies are able to navigate and produce a post-plot map accurately, and when called upon, go back into the field to relocate targets.

Determine If Seafloor Magnetic Anomalies Are "Significant" Archaeological Site

The ultimate goal of an MMS mitigative recommendation is to have the operator or his representative determine if the unidentified magnetic anomaly is a significant archaeological site. The very over-simplified answer to this question is two-fold: (1) put your hands-on the anomaly and tell the MMS what it is, or (2) explain away why you can not find the anomaly.

Once a determination has been made as to the source of magnetic disturbance, an intelligent and cost-effective solution can be made on how to proceed. If the anomaly or cluster of anomalies are modern marine debris, this site is cleared archaeologically. However, if the divers determine the anomalies are suggestive of a historic period shipwreck and the operator wants to proceed, additional surveying and testing will be required. If this site is determined to be significant, the consultation process must begin between the SHPO, ACHP, the MMS and the operator along with an memorandum of agreement to how to proceed signed by all parties. This process and site clearance is very expensive and could take 12 to 18 months.

TODAY'S SITUATION

Engineering Completed Prior to Groundtruthing May Preclude Avoidance

Looking at today's situation with respect to Dr. Irion's and my observations of commercial divers trying to do archaeology under water, we see several problems and we can offers a few solutions. When the MMS archaeologists get the archaeological report and a copy of the proposed pipeline construction route, the project is already designed. Our review and recommendations are based the geophysical report. There is generally no lead time for consultation if a potential problem is identified. I don't know how many times I have been told that the operator has a pipeline construction barge on site standing by "ready to go." There is no additional time built into this scenario to do anything except construct. Solution: get the archaeological survey

reports to us as soon as they are completed and written. Therefore, if a problem develops the operator will have time to re-engineer or spend the appropriate amount of time, technology, and man-power to clear or mitigate a site.

Anomalies Aren't Being Found

Once we make mitigative recommendations and the operator or his representative hires a commercial diving company, the majority of the unidentified magnetic anomalies recorded during the survey are simply not being found. It has been my personal observation that there are serious problems with the current state of the art used by some commercial diving companies when it comes to the search methodology deployed groundtruthing operations.

Projects Are Not Proving "No Adverse Effect"

When these anomalies are not found another problem arises. There can not be a determination of "No Adverse Effect" issued to clear to site. The compliance process breaks down.

Federal Obligations Are Not Being Met

What Happens When the Compliance Process Breaks down? Federal obligation are not met. If "significant," and the key word here is "significant," archaeological resources are injured or destroyed because of construction, and there is the potential for law suits and heavy fines by the Federal Government.

Construction Is Being Delayed and Money Is Being Wasted

What else would happen? Well, construction would be delayed and project costs would go up or, in the worst case, the project could be canceled. The bottom line is that lots of time and money would be wasted paying lawyers and federal fines.

WHY AREN'T ANOMALIES BEING FOUND?

Given the present situation and the available technology, why aren't anomalies being found? To try to come up with an answer, let's look at a worst case scenario. Brand X Oil Company wants to lay a pipeline from Well A to shore. They contracted the Acme Survey Company to run a shallow hazards and archaeology survey. After reviewing Acme's report, the MMS recommended that they avoid or test a cluster of five anomalies on or near the centerline of Brand X's proposed pipeline. Months later, Brand X has completed its engineering and is ready to lay pipe when they call their diving contractor to tell them to jump divers on the five anomalies. Acme Survey is no longer doing Brand X's positioning, so they call Big Easy Survey to position the dive boat. They, in turn, call a contract archaeologist to meet the diveboat at Fourchon at dawn. As the diveboat steams out to the site, the dive master learns for the first time that his crew is doing archaeological, not hazards, testing and the Big Easy Surveyor scrambles to scale off a coordinate from the Anomaly Map provided in Acme's report. By the end of the day, the divers have gotten one hit on their gradiometer, but could not tell what caused it because the bottom was too hard to drive in their rebar probe. Despite a good effort by the divers, they have found no evidence of the other four anomalies at all. What went wrong?

Positioning Errors

We suspect that positioning errors may account for some, if not most, of the problem. Most survey companies are using DGPS for their positioning, which is accurate to within 5 m. However, that position is good for the location of the antenna mounted on the ship. While positions are corrected for sensor layback, there are bound to be some inaccuracies that creep in from the scope of the cable, the effects of current, etc. In addition, survey is conducted *at most* at 50 m intervals. The actual location of the source of the anomaly easily could be 75 feet away. Complicating the picture even further, in the example cited above, the survey company only had a map to go by and had to scale off a position. With the map scale at 1 inch = 1,000 feet, it would be very easy to be off by several tens of feet. To overcome this deficiency, MMS will soon be requiring that Lat/Long positions of magnetic anomalies be supplied in reports. Also, when the Big Easy Survey Co. returned to the position, their DGPS position also was accurate to within 5 m, but it could have been 5 m in the opposite direction from Acme's unit. I think you can begin to see that all these slight inaccuracies add up to the point that when the diver jumps into the water, it would be nothing short of a miracle if he landed anywhere close to the target.

Search Methods

Positioning problems are complicated further by the search methods employed on the seafloor. Because most commercial dive companies practice liveboating,

and all commercial divers are on surface supplied air with an umbilical from the dive platform, their search pattern has generally consisted of a "spoke" pattern rather than the circle search recommended by the MMS. The circle search admittedly was designed for implementation by two divers on SCUBA and did not take into account the problems that created for commercial divers. The problem with the spoke pattern, however, is that there are huge gaps in the coverage of the seafloor, particularly towards the outer ends of the "spokes." The circle search pattern offers better coverage, but is difficult for one diver to do on an umbilical, dangerous when liveboating, and creates problems in using a gradiometer to detect the anomaly source on the bottom by inducing false anomalies when the sensor changes orientation.

Detection Equipment

This leads to another potential problem, which is that of equipment selection. We frequently have found that poor communication between all the different parties has resulted in the dive company being ill prepared when they go into the field. They often may not be aware of the day's task until some unsuspecting archaeologist shows up at the dock or is picked up off a rig. As a result, they probably don't have the specialized equipment to do the job. Who can blame them for being less than pleased? It's embarrassing to the divers, wastes time and money, and creates resentment all around. At a minimum, the following equipment should be on board:

- DGPS positioning
- a magnetometer
- a gradiometer
- a metal detector
- a ten-foot steel probe
- a water jet, airlift, or hand-held dredge
- a non-ferrous weight for the anomaly buoy anchor

Not Enough Bottom Time

A fourth problem may result from the amount of time spent looking for anomalies. The assumption has been in the past that it should take no more than an hour to an hour and a half to locate an anomaly source. If the diver drops on the position and spends this much time probing the spoke pattern and nothing is found, the target is written off. We expect that some anomalies may be found in an hour; others may take longer.

Procedures Not Being Followed

One major problem we have observed is that MMS procedures for locating anomalies are not being followed. These procedures were developed over the course of hundreds of hours under water refining techniques to locate and test magnetic anomalies, and have proven to be effective under the conditions prevalent on the OCS. The bottom line is that diving projects that fail to locate the source of a recommended anomaly and cannot:

a prove that the anomaly no long exists,
b. prove that the anomaly is too deeply buried to be disturbed, or
c. prove that the anomaly is an isolated point source too small to be significant have not complied fully with recommended MMS procedures and are not in compliance with MMS permit requirements.

Original Assumptions That Are No Longer Valid

As it presently stands, certain invalid assumptions have guided the testing of anomalies by commercial diving companies. These are:

1. The position provided in the report is the precise location of the anomaly source.
2. Any piece of metal, no matter how small, found on the seafloor caused the anomaly, no matter how big.
3. If we can't find the anomaly in an hour, its not worth finding.

Much of the problem can be summarized in the adage: "*You Can Teach an Archaeologist to Dive Quicker Than You Can Train a Diver to be an Archaeologist.*" This is by no means meant to put down the efforts of commercial divers, but rather to reflect a difference in training, orientation and approach to this particular, specialized mission. Where commercial divers are trained to perform complex tasks under water, underwater archaeologists are taught to solve a problem. Grounded in the issues of what constitutes an historic site, how magnetic amplitudes relate to physical mass, how clusters of anomalies may relate to one another and what patterns have been observed on other shipwrecks, archaeologists are better prepared to direct this effort than dive supervisors.

AVAILABLE OPTIONS

What Then Are the Available Options for Operators on the OCS?

Commercial diving companies: They clearly have a long and successful record of working with the oil and gas industry and are experienced in oilfield conditions. They generally are on site for other inspection or construction purposes and can *mobilize quickly.* However, they generally are *inexperienced in archaeological methods* of search and excavation, and simply don't know what to look for when it comes to distinguishing a significant archaeological site.

Consulting Archaeologists: These individuals are trained archaeologists who are *experienced in identifying archaeological resources* and are *experienced in methods of search and excavation.* To employ these firms, however, probably would require more pre-planning on the part of the operator. They would require *more advance notification* to mobilize and schedule, they may be *more restricted by weather* or environmental conditions and they probably are *limited by vessel availability,* since none of these firms is large enough to own their own ship for offshore work.

Based on our analysis, the costs should be about the same between the two groups.

RECOMMENDATIONS

Work More Closely with Archaeologists

This would include better pre-dive coordination between the operator, the survey company, the consulting archaeologists, and the MMS. The MMS requires a two-week notification to the Field Operations coordinator prior to initiating diving operations. We also encourage pre-dive coordination between the consulting archaeologist and the MMS archaeologists and also welcome calls from the field over developing issues or concurrence with findings.

Improve Positioning

One problem in the past has been that anomaly locations were provided to the MMS in the form of line numbers and shot points. Many survey companies now are providing us real world coordinates. Soon, we will begin requiring these data so that there is no question about the starting point for the search.

Use a Stable Work Platform

If possible, we encourage the use of an anchored vessel or barge. Liveboating procedures are not really appropriate to this mission and hamper search methods.

Improve Search Procedures

Alternatives to the spoke search pattern should be employed. Earlier, we reviewed the effectiveness of the spoke method versus the circle search method. Other methods could be tried including the square search and the sweep method.

Make Sure You Have the Proper Equipment

Again, coordination is the key to a successful mission. The proper search equipment must be on board. You MUST be able to re-find the anomaly location on the seafloor and I think it is safe to assume that the coordinate you have in front of you probably is NOT the precise location of the target. Before putting divers in the water, it is a good idea to run a mini-magnetometer survey over the area to refine the target location. You may even find that the anomaly has been moved by storms or shrimp trawlers and is no longer a concern. When the divers go in the water, they must have some sort of detecting device, either a gradiometer or metal detector to guide the probing effort. You should all also be aware of a new diver-held cesium magnetometer leased and sold by Geometrics, Inc. We hope to test the effectiveness of this device for use on the OCS. In addition, the divers should have access to some sort of hand-held excavation device, either a water jet, air lift, or dredge, in the event that the anomaly is buried and can not be delineated with a probe.

Take the Time Necessary to Do the Job

Finally, it is absolutely necessary to take the time to complete the mission and to take a flexible approach in re-locating and testing the anomalies.

WHEN IS THE JOB FINISHED?

The Job is Finished When the Archaeologist has determined that the proposed project will have: "*No Adverse Effect!*"

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Richard (Rik) J. Anuskiewicz was awarded his B.A. in 1972 and his M.A. in 1974 in Anthropology, with specialization is archaeology from California State University at Hayward. He was employed with the U.S. Army Corps of Engineer Districts of San Francisco, Savannah, and New England Division from 1974 to 1984, as a terrestrial and underwater archaeologist. Since 1984 he has worked at his present position with Department of the Interior, Minerals Management Service, Gulf of Mexico Region as a marine archaeologist. Dr. Anuskiewicz received his Ph.D. in 1989 in anthropology, with specialization in marine remote-sensing and archaeology from the University of

Tennessee at Knoxville. His current research interest is focused on using remote-sensing instrumentation as a tool for middle-range theory building through the correlation of instrumental signatures to specific observable archaeological indices.

Dr. Jack B. Irion joined the Minerals Management Service, U.S. Department of the Interior, in August, 1995, with the title of marine archaeologist. He received his B.A. (1974) and M.A. (1977) in archaeological studies from The University of Texas at Austin. He was awarded his Ph.D. from the Institute of Latin American Studies of the University of Texas in 1991. During his career, Dr. Irion has specialized in conducting remote sensing surveys for shipwrecks, which succeeded in locating such historically significant vessels as the C.S.S. *Louisiana*, the sailing barque *Maxwell*, and the steamboats *Princess*, and *Kentucky*. In addition, he has directed numerous diving investigations on historic shipwrecks, including most recently the steamship *Columbus* and the Civil War gunboats *Tawah* and *Key West*.